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Viewpoint

Evidence of Foodborne Transmission of the Coronavirus (COVID-19) through the Animal Products Food Supply Chain

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The coronavirus (COVID-19) pandemic caused by the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in significant social disruptions and human costs. The predominant transmission routes are conjectured to be inhalation of airborne virus and contact with fomites on shared surfaces. Recently, COVID-19 infection clusters have been reported related to the fresh meat and seafood industry in different countries which caused concerns about the foodborne transmission of SARS-CoV-2 to the human population.

Transmission of SARS-CoV-2 and its variants between live animals and humans has recently been reported at mink farms in several countries, such as Denmark, the U.S., Netherlands, and Spain.[1] In Denmark, over two hundreds human cases of COVID-19 were infected by a specific mink-associated SARS-CoV-2 variant, resulting in the culling of minks in the country to preventing humans from infection. The U.S. Department of Agriculture has confirmed SARS-CoV-2-infected live animals, including farmed minks, household cats and dogs, and tigers. Thus, the potential transmission loop of SARS-CoV-2 spreading from humans to animals and back to humans has announced serious concern.[1,2] In summary, there is growing consensus that both farmed and household animal species can be host for SARS-CoV-2 variants, and future research should focus on revealing the possible transmission pathways.

Frequent outbreaks of COVID-19 infections have also been reported among workers in slaughtered meat processing plants in different countries, such as Canada, Brazil, Germany, and Ireland. In Auckland, New Zealand, four new COVID-19 infected cases were reported in August 2020 following a period of no new infections for more than 100 days in the country, one of whom was a worker engaged in handling frozen food. In Qingdao, China, two dockers handling imported frozen seafood tested positive which resulted in a small-scale COVID-19 outbreak.

At the end of meat and seafood supply chain, such as food markets and grocery outlets, COVID-19 clusters have also been reported. In Beijing, China, after no local cases had been reported for 56 days, a new COVID-19 cluster was reported by the China Centers for Disease Control and Prevention (CDC) on June 11, 2020, with most cases traced to the Xinfadi Wholesale Food Market, the largest wholesale market for agricultural products in Beijing, providing fruits, vegetables, and seafood and meat in fresh or frozen packaging.[3] The source of the infection was traced to imported frozen salmon.[3]

During the food processing of infected animals, including slaughtering, dissecting and packaging, the food, its packages, and the associated environments could be contaminated by SARS-CoV-2. Although it is hard for SARS-CoV-2 to replicate after leaving the host, evidence exists that the virus can survive even on frozen surfaces for prolonged periods of transit and export.[2−4] As the dose of most of respiratory viruses needed for

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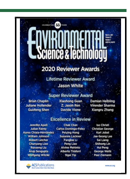

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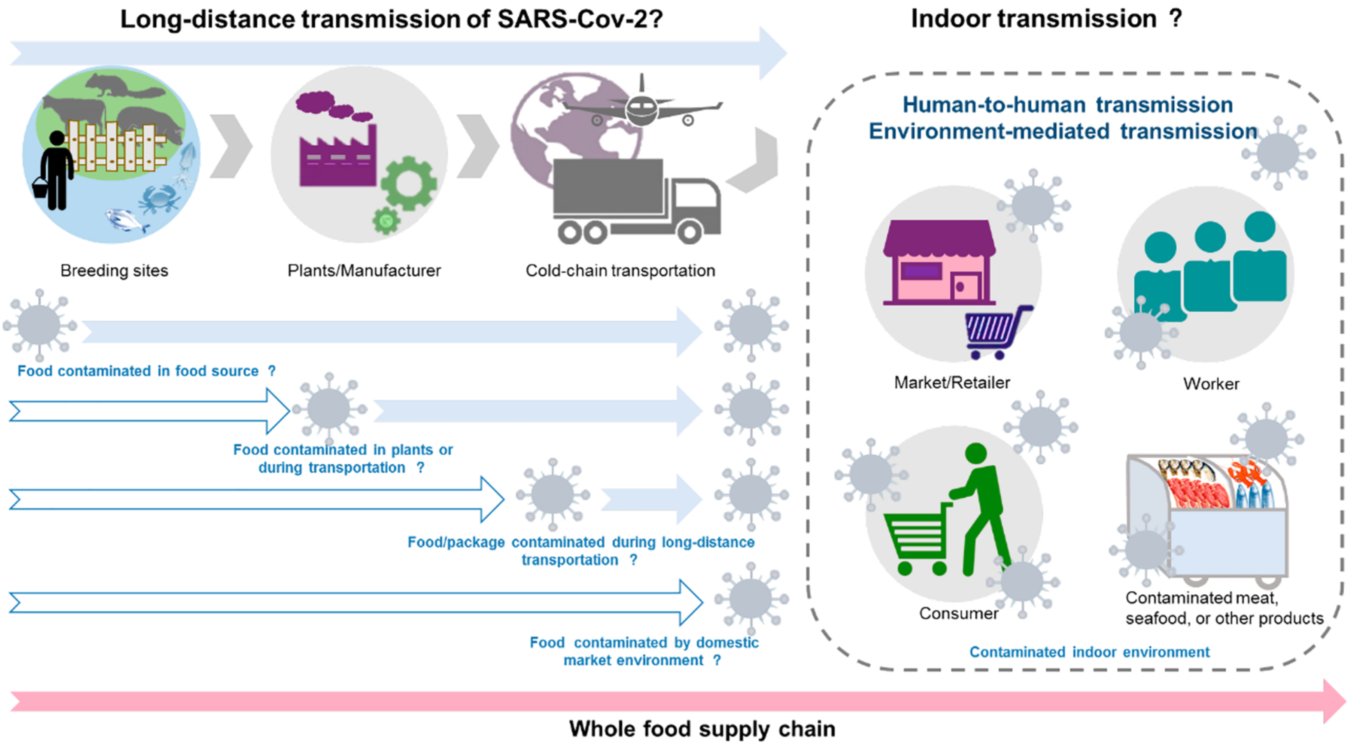

Figure 1. Possible food-associated transmission routes of COVID-19.

infection is low, survival of low levels of the virus on globally exported meat and seafood products may lead to the global spread and resurgence of COVID-19 via the cold food supply chain. Similarly, infected workers may also transmit the virus into the animal food chain.

Overall, various evidence highlights the considerable risk of transmission and infection of SARS-CoV-2 throughout the fresh and frozen animal produce supply chain, from initial breeding, intermediate processing, to terminal sales (Figure 1). Most of the current knowledge on the risk of environmental transmission of SARS-CoV-2 through the food chain is based on previous studies of other CoVs, such as SARS-CoV-1 and MERS-CoV,[4] but not SARS-CoV-2. Enveloped viruses are typically adsorbed on surfaces via electrostatic, van der Waals, and hydrophobic interactions,[5] which is highly dependent on the properties of different surface. To investigate the surface behavior of SARS-CoV-2 under real scenarios,[6,7] the precise characterization of the surface properties and the associated microenvironment such as humidity, pH, and biofluid is needed. In addition, more attention should be paid to the adsorption and desorption characteristics of SARS-CoV-2 at cellular/tissue surfaces as food product to evaluate the viability of SARS-CoV-2. Based on this understanding of the underlying adsorption and survival mechanisms, new packaging and shipment surface materials could be designed to reduce or prevent the viability of SARS-CoV-2.

In addition, disinfection remains another essential tool in the prevention of foodborne transmission of SARS-CoV-2. Ultraviolet light is currently used for the disinfection of SARS-CoV-2 on the surface of imported packages.[8] However, given the frequent and extensive infection processes that would currently be required combined with the health concerns regarding the use of the disinfection products, alternative ideas are still needed for the development of effective disinfection methods with low side effects.

One alternative is the routine surveillance of SARS-CoV-2 (or its variants) in all meat and seafood for consumption. This would make a significant contribution to the prevention and control of foodborne transmission of the virus. For example, routine sampling and surveillance of SARS-CoV-2 on the imported food arriving in Tianjin, a port city in China, reported the positive testing of SARS-CoV-2 in imported pork in November 2020. Simultaneously, three new COVID-19 cases were traced and confirmed by workers involved in handling these contaminated imported foods. We propose the genetic sequencing of SARS-CoV-2 in animals destined for the food industry should be included in the routine surveillance of animal farming. This will be of benefit to trace the source, mutation of SARS-CoV-2 and the potential hosts as SARS-CoV-2 vectors in food-providing animals. In addition, although there is no report on the infection because of the contamination of plant-based products, they may also be an important vector to mediate the infection of SARS-CoV-2. Therefore, facing with the emerging vectors for the transmission of SARS-CoV-2, analytical throughput and information acquisition in the surveillance of SARS-CoV-2 is still the major challenge and the development of high-throughput monitoring methods are needed for the analysis of large volumes of imported foods.[9] However, it remains arguably the most effective and feasible measure to detect infected food products and prevent foodborne transmission. The abundance of SARS-CoV-2 in the environment should be accurately determined based on a standardized method, including standards of sampling, pretreatment, storage, and quantitative/qualitative analysis, and applied for the comparison of different processes, especially for the global food supply chain. The integrity and viability of SARS-CoV-2 on packaged, stored and transported materials need to be evaluated, and the relationship between abundance, viability, and infectivity of SARS-CoV-2 should be established.[10,11]

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While new foodborne transmission vehicles and viral mutations may still emerge in an unexpected manner, hampering our surveillance and control of the pandemic and resulting in the resurgence of COVID-19 or similar infectious disease, the underlying knowledge of SARS-CoV-2 vectors is important for policymakers to improve the current surveillance and disinfection strategies for the maintenance of the normal global food supply chain and the associated international trade and economy during the pandemic. We have acquired extensive experience in physical distancing, lockdowns, mask use, and movement restrictions for controlling this pandemic. However, our scientific understanding on the effective control strategies for the pandemic is still limited, and additional research is imperative to combat emerging COVID-19 transmission vehicles that are currently out of sight.

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Notes

The authors declare no competing financial interest.

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